

August 1993

Preliminary Data Summary

by **Field Research Facility**

**U.S. Army Corps of Engineers
Waterways Experiment Station
Coastal Engineering Research Center
1261 Duck Road
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Preface

This report provides a summary of basic oceanographic, meteorological and bottom profile data for the month. The data were obtained as part of the Measurements and Analysis work units at the U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's Field Research Facility (FRF) in Duck, North Carolina. The FRF staff collected and analyzed these data. These summaries are intended to make the data readily available to all FRF users, and comments on their content and usefulness are invited.

Author's note:

The gauges of the "8-Meter Array" were being replaced this month. A self-recording pressure gauge and current meter (gauges 3511, 3559, 559, 569) were substituted for the "8-Meter Array" (3111) and for the FRF pressure gauge and current meter (gauges 511, 519, 529). The affected dates are from August 11th through the remainder of the month.

1 Introduction

The U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's (CERC) Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. The research pier is a reinforced concrete structure supported on 0.9-m-diam steel piles spaced 12.2 m apart along the pier's length and 4.6 m apart across the width. The pier deck is 6.1 m wide and extends from behind the duneline to about the 6-m water depth contour at a height of 7.75 m above the National Geodetic Vertical Datum (NGVD) of the year 1929.

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local bathymetric, oceanographic, and meteorological conditions. This summary is intended to provide basic data as soon as possible after they are obtained. Questions and/or comments concerning the data may be directed to Mr. Clifford F. Baron at (919) 261-3511.

Chapter 2 presents the meteorological data; Chapters 3 through 6 present oceanographic data; Chapter 7 presents nearshore profiles and bathymetry; and Chapter 8, if included, documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used and their operational status during the month. Table 2 and Figure 3 identifies the location of the instruments. Figure 2 shows weather and ocean conditions for the month. The water depths at the wave gauges and current meters vary and may be determined from information contained in Figure 9. Other installation information is contained in Table 1.

Times given in the report are referenced to eastern standard time (EST).

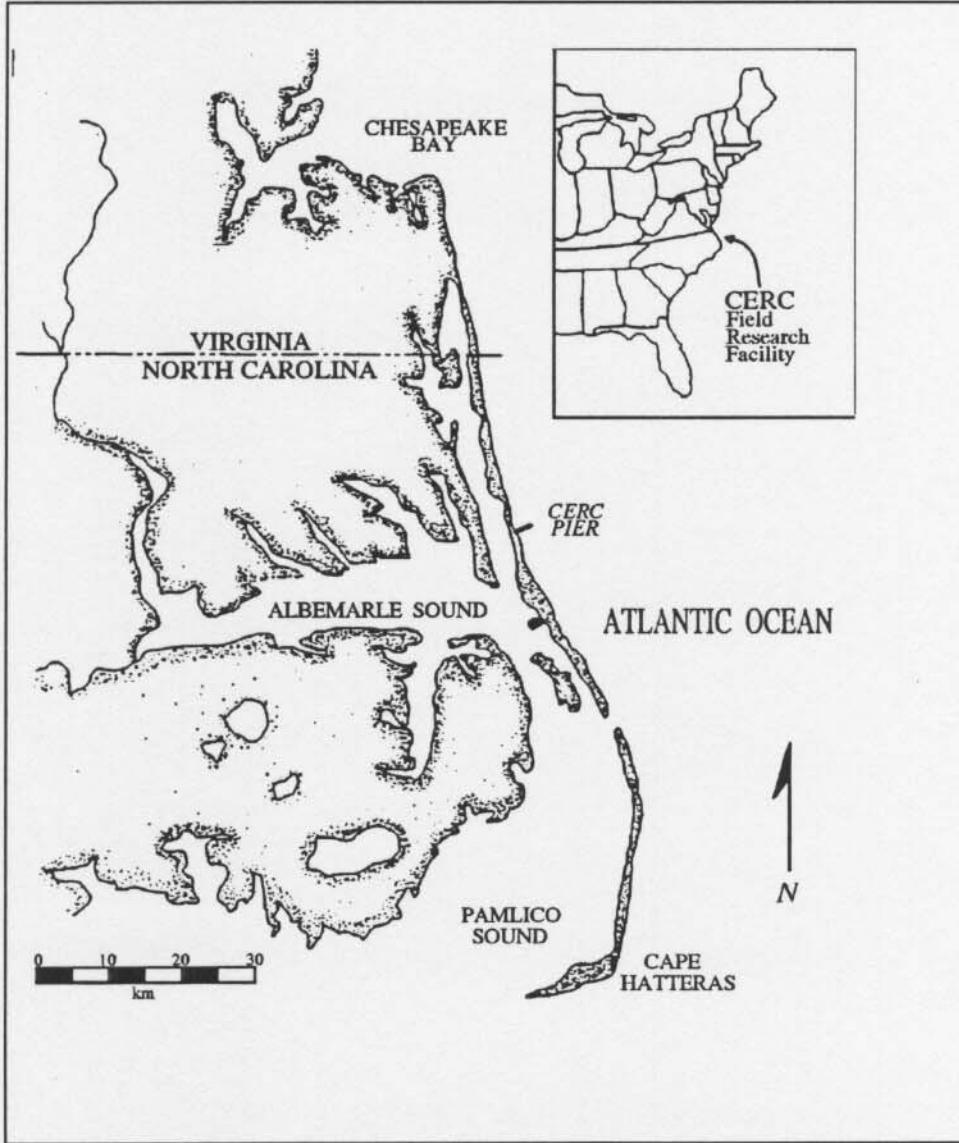


Figure 1. FRF Location Map

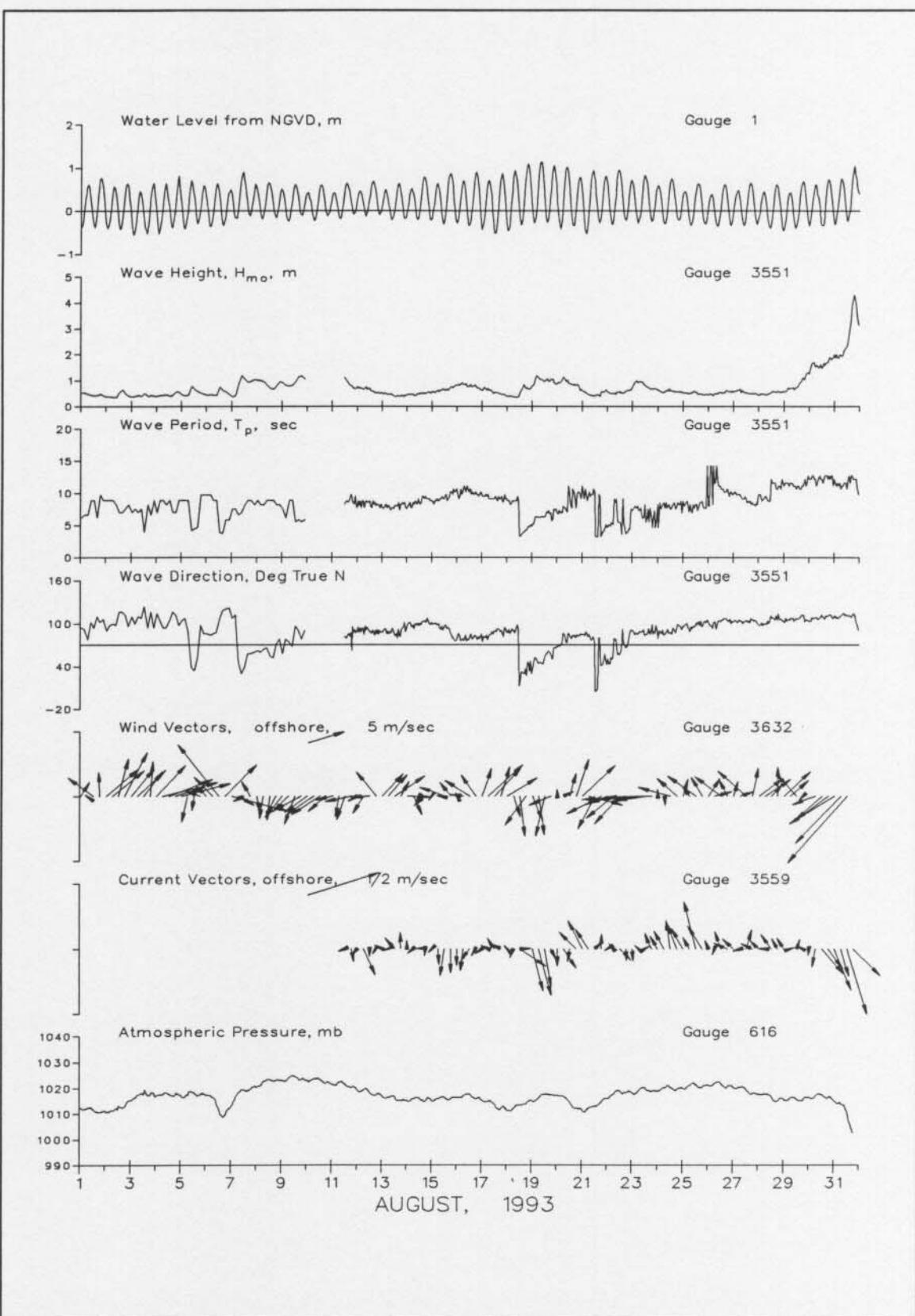


Figure 2. Month at a Glance

Table 1
Instrument Status/Data Availability

Gauge ID	Description/Remarks		August 1993																													
			Day of the month																													
1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1		
616	Atmospheric Pressure	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
604	Precipitation	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
624	Air Temperature	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/	*	
632	Anemometer on top of building	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
932	Anemometer at seaward end of pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
641	Pressure Gauge at station 780 on FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
625	Baylor staff at station 1860 on FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/	
3111	8 Meter Array 243 m north of FRF	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	Gauge 3551 -->	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
511	Pressure Gauge 243 m north of FRF pier (0.9 km offshore)	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	Gauge 551 -->	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
630	Waverider buoy 4.0 km offshore	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/
519	Current meter 320 m north of FRF pier (0.9 km offshore)	Gauge Status	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Gauge 559 -->	*				
		Data Collected	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*			
1	NOAA tide station at seaward end of FRF pier	Gauge Status	*	*	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Visual Observations (daily oceanographic and meteorological observations)	Daily observation	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Gauge Status * = Operational / = Partial - = Non-Operational
 Data Collected * = All / = Partial - = None
 Visual Observations * = Complete / = Partial - = None

Table 2
Gauge Locations

Gauge ID	Description	Latitude Degrees N	Longitude Degrees W	FRF Coordinates X, m Y, m		Gauge Depth NGVD, m	Water Depth NGVD, m
616	Barometer	36 10' 45.48"	75 44' 37.39"	11.60	569.00	----	----
632	Building Anemometer	36 10' 45.24"	75 44' 39.53"	21.45	515.83	19.94	----
932	EOP Anemometer	36 11' 2.64"	75 44' 46.50"	585.20	517.30	19.5	----
641	780 Pressure	36 10' 51.96"	75 44' 42.21"	239.11	516.64	-1.64	-1.96
625	1860 Baylor	36 11' 2.10"	75 44' 46.31"	568.00	516.64	Surface	-8.36
3111	8m Array	36 11' 15.90"	75 44' 38.88"	914.43	825.52	-7.76	-8.08
511	Pressure N Tripod	36 11' 15.95"	75 44' 38.69"	914.36	830.46	-6.86	-7.94
630	Waverider	36 12' 16.44"	75 47' 19.23"	3934.96	-2400.81	Surface	-17.0
519	Current N tripod	36 11' 15.95"	75 44' 38.69"	914.36	830.46	-5.55	-7.94
1	NOAA Tide	36 11' 2.95"	75 44' 46.76	596.49	514.2	Surface	-7.62

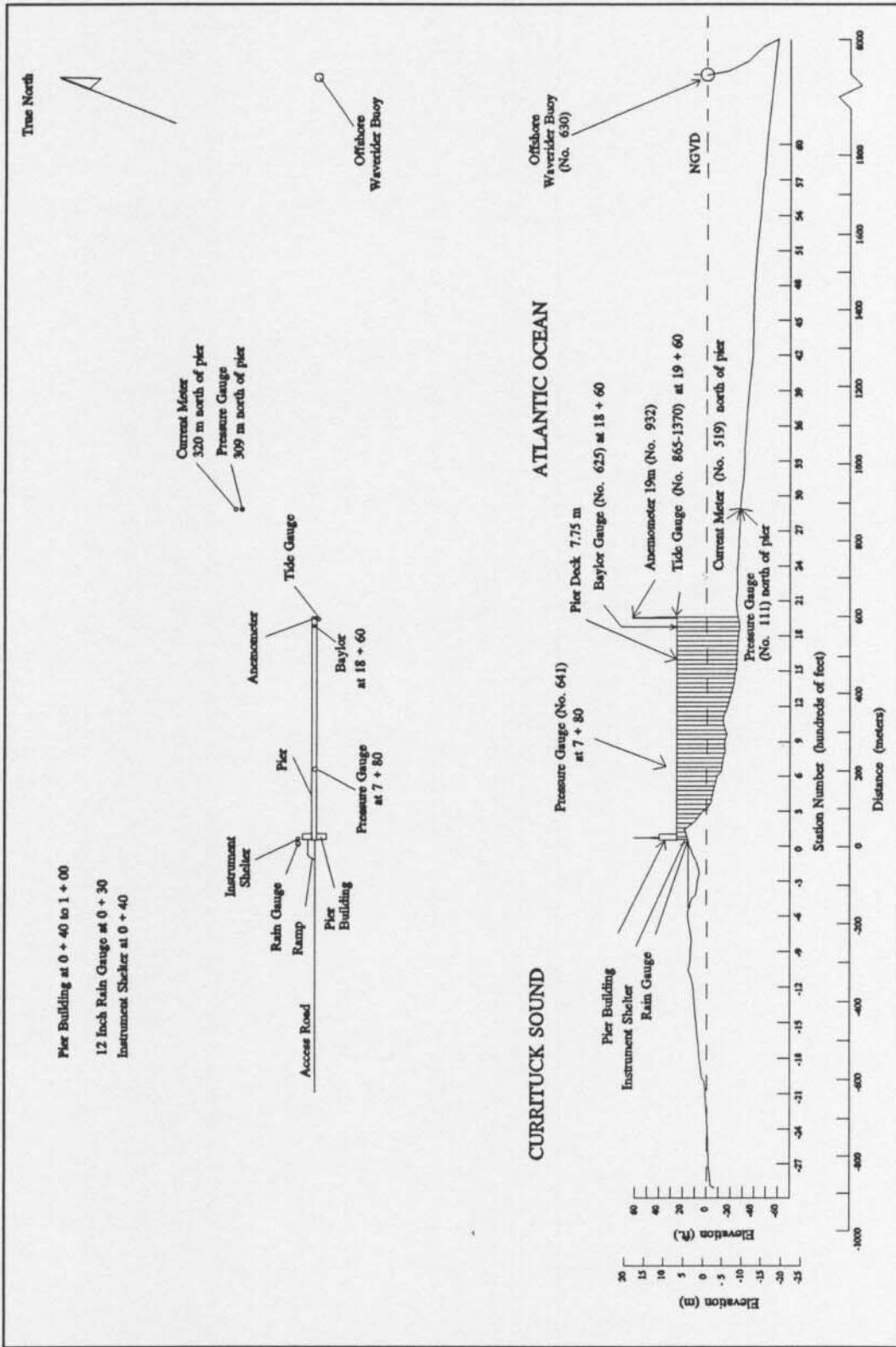


Figure 3. Instrument Locations, Elevations From NGVD

2 Meteorological Data

A variety of instruments have been installed at the FRF (Figure 3) to monitor the meteorological conditions. The data presented in Table 3 are collected and stored using a Digital Equipment Corporation VAX 11/750. For each instrument identified in Table 1, a log is maintained and the records are stored for future reference.

Winds were measured at the end of the pier at an elevation of 19 m (Figure 4) using a WeatherMeasure Skyvane anemometer. Monthly resultant wind speeds and directions are determined by vector averaging the data. Wind directions indicate where the wind is coming from. Temperature and atmospheric pressure means are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 3 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -
 $mm \times .03937 = in.$
2. Millibars (mb) to inches of mercury (in. Hg) -
 $mb \times 0.02953 = in. Hg$
3. Degrees Celsius (C) to degrees Fahrenheit (F) -
 $(C \times 9/5) + 32 = F$
4. Meters per second (m/s) to knots (kn) -
 $m/s \times 1.943 = kn$

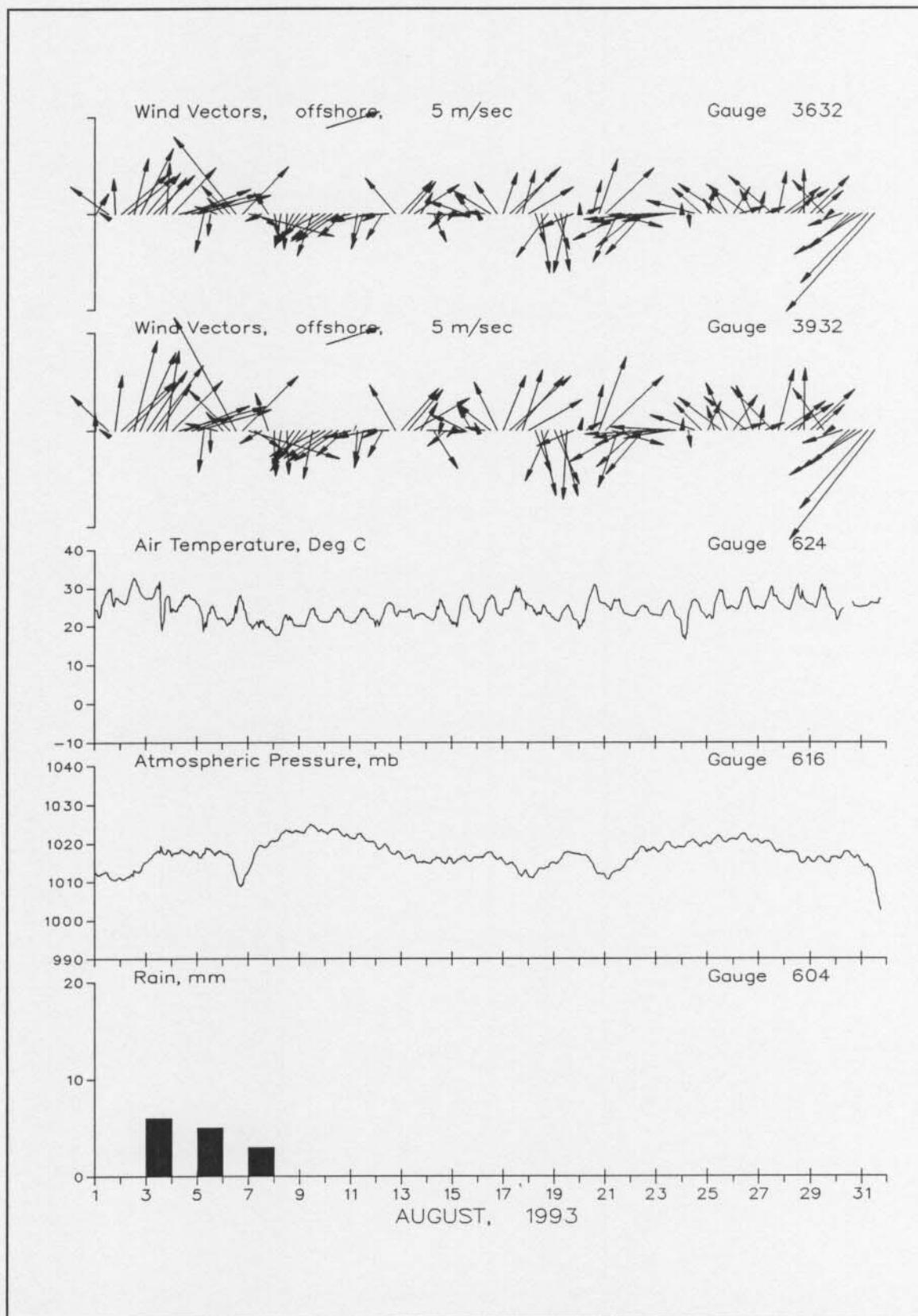


Figure 4. Meteorological Monthly Summary

Table 3
Meteorological Data

August 1993						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
1	100	2	179	24.4	1012.6	0
	700	0		25.8	1012.2	0
	1300	5	137	29.8	1011.8	0
	1900	6	186	26.8	1010.6	0
2	100	7	223	26.5	1010.9	0
	700	7	222	27.5	1011.5	0
	1300	9	192	32.8	1013.3	0
	1900	9	201	28.9	1012.9	0
3	100	7	210	27.2	1015.3	0
	700	8	213	27.8	1017.2	0
	1300	5	210	31.8	1017.6	0
	1900	8	188	27.4	1017.4	6
4	100	7	221	24.7	1017.1	0
	700	8	252	25.2	1017.6	0
	1300	6	246	27.3	1017.7	0
	1900	4	249	27.3	1017.3	0
5	100	7	251	25.9	1017.2	0
	700	4	6	19.4	1017.4	0
	1300	2	1	24.7	1018.4	5
	1900	3	104	22.4	1017.7	0
6	100	2	141	21.9	1017.4	0
	700	5	138	20.8	1016.5	0
	1300	13	154	23.9	1012.1	0
	1900	7	221	26.4	1009.3	0
7	100	9	289	20.8	1013.3	3
	700	3	308	20.5	1017.7	0
	1300	2	55	21.1	1019.4	0
	1900	4	163	19.9	1019.6	0
8	100	4	1	17.8	1020.5	0
	700	5	6	18.8	1022.5	0
	1300	5	358	22.0	1023.4	0
	1900	4	29	20.4	1023.0	0
9	100	5	31	20.0	1022.9	0
	700	4	40	21.2	1023.9	0
	1300	5	9	24.5	1024.6	0
	1900	5	58	21.4	1023.1	0
10	100	5	52	21.1	1023.0	0
	700	5	51	22.2	1023.6	0
	1300	5	1	24.3	1023.4	0
	1900	4	43	21.7	1021.9	0

Table 3
Meteorological Data (continued)

August 1993						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
11	100	2	72	20.9	1021.5	0
	700	3	3	22.1	1022.5	0
	1300	4	11	24.8	1021.5	0
	1900	3	76	22.1	1020.3	0
12	100	2	58	21.3	1019.1	0
	700	3	25	22.7	1019.2	0
	1300	2	87	26.1	1018.3	0
	1900	5	153	23.2	1017.3	0
13	100	5	217	23.7	1016.9	0
	700	5	216	23.9	1016.4	0
	1300	6	236	21.9	1016.5	0
	1900	3	207	23.2	1015.0	0
14	100	3	272	22.2	1015.0	0
	700	4	331	21.8	1015.7	0
	1300	0		27.1	1016.2	0
	1900	2	44	23.0	1014.9	0
15	100	1	37	20.5	1015.0	0
	700	0		22.9	1016.0	0
	1300	3	117	27.7	1016.4	0
	1900	3	153	23.9	1015.7	0
16	100	1	160	21.4	1016.4	0
	700	2	100	24.2	1017.1	0
	1300	4	132	27.8	1017.7	0
	1900	5	157	23.7	1015.9	0
17	100	6	199	24.5	1015.2	0
	700	8	224	25.2	1015.0	0
	1300	7	217	30.5	1013.6	0
	1900	6	196	27.0	1011.9	0
18	100	6	236	25.4	1011.2	0
	700	5	342	23.2	1012.2	0
	1300	7	349	23.8	1013.5	0
	1900	6	20	23.3	1013.9	0
19	100	6	338	21.6	1014.9	0
	700	7	347	22.4	1016.0	0
	1300	7	3	25.3	1017.7	0
	1900	4	63	21.8	1017.3	0
20	100	1	190	19.6	1017.2	0
	700	2	238	24.4	1016.7	0
	1300	5	191	30.0	1014.5	0
	1900	8	197	26.7	1012.3	0

Table 3
Meteorological Data (concluded)

August 1993						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
21	100	8	222	25.7	1011.1	0
	700	5	288	24.5	1012.3	0
	1300	6	16	26.7	1013.1	0
	1900	6	56	23.2	1014.4	0
22	100	3	64	22.7	1015.9	0
	700	5	44	23.8	1017.6	0
	1300	6	36	25.4	1018.9	0
	1900	6	86	23.2	1018.2	0
23	100	6	82	22.9	1018.1	0
	700	4	76	24.2	1019.0	0
	1300	4	79	26.5	1020.2	0
	1900	6	93	22.4	1018.8	0
24	100	1	185	18.4	1018.9	0
	700	2	353	23.3	1020.3	0
	1300	4	111	26.8	1020.3	0
	1900	4	139	23.6	1019.6	0
25	100	3	201	22.5	1019.9	0
	700	3	165	24.9	1021.1	0
	1300	5	131	29.4	1021.4	0
	1900	5	159	24.3	1020.4	0
26	100	4	210	24.8	1021.1	0
	700	2	252	25.5	1021.9	0
	1300	5	132	29.8	1021.8	0
	1900	5	162	25.1	1020.4	0
27	100	3	189	24.8	1020.3	0
	700	2	246	26.1	1020.5	0
	1300	6	140	30.3	1019.5	0
	1900	6	192	26.4	1018.0	0
28	100	5	230	24.8	1017.6	0
	700	5	234	25.2	1017.8	0
	1300	3	214	30.9	1016.8	0
	1900	6	180	27.0	1015.0	0
29	100	6	223	25.5	1015.5	0
	700	3	223	25.6	1016.2	0
	1300	5	147	29.3	1015.7	0
	1900	1	49	25.6	1015.2	0
30	100	1	85	21.8	1016.4	0
	700	4	68	24.5	1016.9	0
	1300	5	43	Inoperative	1017.5	0
	1900	6	50	25.1	1016.2	0
31	100	8	53	25.1	1014.9	0
	700	10	36	25.5	1013.9	0
	1300	14	33	25.9	1010.7	0
			Hardware Error			0
			Resultant	Mean	Mean	Total
		1	153	24.4	1017.2	14

3 Wave Data

Wave data are collected from a Baylor staff gauge (Gauge 625), two pressure wave gauges (641 and 511) and a Waverider buoy (Gauge 630) as shown in Table 1 and Figure 3. The data are collected, analyzed, and stored on optical disc using a Digital Equipment Corporation VAX 11/750 programmed to sample the gauges for two hour and forty-eight minute time frames. The sampling rate is two times per second which equals five contiguous 34 minute records per collection period. This report reflects the data collection periods of 0100, 0700, 1300, and 1900 EST. The results are based only on the first 34 minute record.

Wave height H_{mo} is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gauge has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 deg of freedom calculated from a 34-min record. Peak wave period T_p is defined as the period associated with the maximum energy in the spectrum. When this analysis is complete, the data are written to optical disc.

Table 4 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 4 are average values computed from this data. Figure 5 is a time history of all H_{mo} and T_p values obtained for all gauges.

Differences in wave periods between wave gauges (Table 4 and Figure 5) may be the result of wave breaking, wave reformation, the presence of multiple wave trains containing nearly equal energy, and statistical variations in spectral estimations.

Table 4
Wave Data

August 1993									
Day	Hour	641		625		551		630	
		Pressure Gauge Hmo,m	Tp,sec	Baylor 1860 Hmo,m	Tp,sec	Pressure Gauge Hmo,m	Tp,sec	Waverider Hmo,m	Tp,sec
1	0100	0.18	4.74	0.46	6.09	0.53	6.19	0.54	6.56
	0700	0.21	5.45	0.42	6.56	0.46	6.59	0.49	6.40
	1300	0.15	5.12	0.34	8.53	0.40	8.87	0.41	8.53
	1900	0.27	5.69	0.43	6.09	0.48	9.71	0.59	3.33
2	0100	0.17	4.83	0.32	8.83	0.37	8.87	0.46	9.14
	0700	0.20	5.33	0.30	9.14	0.35	8.87	0.43	8.26
	1300	0.19	9.48	0.40	7.31	0.54	7.04	0.59	7.11
	1900	0.33	6.24	0.43	7.11	0.48	7.56	0.59	7.76
3	0100	0.15	7.31	0.35	7.76	0.37	7.04	0.42	7.11
	0700	0.24	6.92	0.37	6.74	0.42	7.04	0.48	6.74
	1300	0.17	4.49	0.34	7.31	0.51	4.01	0.43	7.31
	1900	0.25	5.33	0.36	8.53	0.42	6.59	0.49	6.74
4	0100	0.17	4.66	0.34	8.83	0.40	7.04	0.50	8.53
	0700	0.25	7.76	0.38	8.53	0.43	8.87	0.52	8.26
	1300	0.19	5.12	0.35	8.53	0.39	8.87	0.39	8.83
	1900	0.35	7.31	0.45	7.11	0.56	7.04	0.59	8.26
5	0100	0.23	4.92	0.39	8.83	0.43	8.87	0.51	8.83
	0700	0.21	8.53	0.32	8.53	0.43	8.87	0.49	8.53
	1300	0.38	4.20	0.63	4.20	0.65	4.54	0.77	4.74
	1900	0.28	4.74	0.48	4.83	0.50	9.71	0.57	4.83
6	0100	0.21	4.13	0.42	9.14	0.42	9.71	0.47	9.14
	0700	0.20	9.48	0.40	8.83	0.42	8.87	0.44	8.83
	1300	0.45	3.56	0.72	3.41	0.75	3.86	0.75	3.56
	1900	0.45	5.22	0.56	5.82	0.56	5.84	0.78	5.12
7	0100	0.19	6.09	0.36	6.09	0.37	7.56	0.49	6.74
	0700	0.32	3.88	0.52	7.31	0.87	6.59	0.59	7.31
	1300	0.59	7.76	0.97	7.53	1.05	8.16	1.16	7.11
	1900	0.37	8.83	0.94	9.14	0.97	8.87	1.11	9.14
8	0100	0.43	8.83	0.98	8.83	1.02	8.87	1.06	8.83
	0700	0.34	4.66	0.88	8.00	0.95	8.16	0.98	8.26
	1300	0.32	8.83	0.62	8.83	0.69	8.87	0.70	9.48
	1900	0.27	7.53	0.74	8.53	0.80	8.16	0.82	7.11
9	0100	0.37	4.83	0.92	6.40	0.92	7.56	0.99	5.95
	0700	0.28	3.51	0.74	4.49	0.78	8.87	0.77	8.26
	1300	0.35	4.49	0.85	8.26	0.94	5.52	0.92	8.83
	1900	0.42	3.41	1.14	6.09	1.17	5.52	1.25	6.09
10	0100	0.41	4.83	0.94	5.33	1.06	5.84	0.99	8.26
	0700	0.34	3.77	0.88	5.95			0.96	8.00
	1300	0.46	4.57	0.98	5.45			1.08	5.82
	1900	0.29	3.61	0.82	5.45	Gauge Inoperative		0.89	7.11

Table 4
Wave Data (continued)

August 1993									
Day	Hour	641		625		551		630	
		Pressure Gauge Hmo,m	Tp,sec	Baylor 1860 Hmo,m	Tp,sec	Pressure Gauge Hmo,m	Tp,sec	Waverider Hmo,m	Tp,sec
11	0100	0.31	5.02	0.69	8.00	Inoperative		0.76	8.00
	0700	0.26	9.48	0.80	9.48			0.91	8.83
	1300	0.36	9.14	0.94	9.14	1.03	8.53	1.01	8.83
	1900	0.26	9.14	0.71	8.53	0.76	8.87	0.85	9.14
	0100	0.28	8.83	0.70	9.14	0.74	8.83	0.81	8.53
12	0700	0.21	8.53	0.65	8.00	0.68	7.76	0.73	8.26
	1300	0.30	8.53	0.60	8.83	0.60	8.00	0.65	8.26
	1900	0.19	9.14	0.51	8.83	0.52	8.26	0.55	8.26
	0100	0.20	12.80	0.49	7.31	0.47	7.53	0.57	7.76
13	0700	0.16	14.22	0.43	7.11	0.46	8.00	0.48	7.31
	1300	0.19	15.06	0.36	8.26	0.39	8.00	0.44	8.00
	1900	0.19	8.26	0.37	8.53	0.42	8.26	0.41	7.53
	0100	0.20	8.53	0.42	8.00	0.47	8.00	0.50	7.76
14	0700	0.19	8.53	0.40	8.00	0.41	8.26	0.54	8.26
	1300	0.27	9.85	0.49	8.53	0.53	8.26	0.57	8.53
	1900	0.29	9.48	0.48	9.48	0.51	9.14	0.57	9.85
	0100	0.27	9.14	0.55	9.14	0.58	8.83	0.67	9.14
15	0700	0.26	9.48	0.57	9.14	0.57	8.83	0.61	9.48
	1300	0.25	9.14	0.66	9.14	0.61	9.48	0.68	9.14
	1900	0.32	9.14	0.74	9.14	0.76	10.24	0.74	9.14
	0100	0.28	9.14	0.85	9.48	0.80	9.85	0.82	9.85
16	0700	0.33	9.14	0.77	10.67	0.87	11.13	0.90	10.67
	1300	0.23	10.24	0.69	10.24	0.83	10.67	0.81	9.85
	1900	0.32	9.14	0.68	9.85	0.72	9.85	0.75	10.24
	0100	0.19	9.48	0.60	9.48	0.63	9.48	0.72	9.48
17	0700	0.27	9.14	0.57	9.14	0.63	9.14	0.65	9.48
	1300	0.15	9.48	0.47	9.48	0.52	9.48	0.56	9.14
	1900	0.25	8.83	0.46	8.53	0.44	9.48	0.60	8.83
	0100	0.14	8.83	0.36	9.14	0.36	8.83	0.41	9.48
18	0700	0.21	8.83	0.35	9.14	0.37	8.83	0.39	8.83
	1300	0.36	3.28	0.60	3.16	0.57	3.37	0.68	3.51
	1900	0.52	4.41	0.75	4.27	0.71	4.27	0.73	4.20
	0100	0.46	5.02	0.75	5.57	0.81	5.33	0.96	5.33
19	0700	0.80	6.24	1.07	5.69	1.05	6.24	1.31	6.40
	1300	0.53	6.92	1.00	6.74	0.99	6.40	1.16	6.74
	1900	0.57	5.02	0.99	7.31	1.05	5.69	1.13	7.76
	0100	0.26	4.06	0.82	7.11	0.93	6.74	0.88	7.31
20	0700	0.42	7.76	0.98	8.00	1.08	7.76	1.02	6.56
	1300	0.23	10.67	0.82	9.85	0.87	8.26	0.86	8.00
	1900	0.30	10.67	0.76	10.24	0.84	9.85	0.91	9.14

Table 4
Wave Data (concluded)

August 1993									
Day	Hour	641		625		551		630	
		Pressure Gauge	Baylor	1860	Pressure Gauge	Waverider	Hmo,m	Tp,sec	Hmo,m
21	0100	0.19	10.67	0.56	10.24	0.57	10.24	0.58	10.67
	0700	0.17	10.24	0.40	10.24	0.44	10.24	0.45	9.48
	1300	0.29	3.12	0.55	3.20	0.43	3.33	0.56	9.14
	1900	0.38	3.77	0.63	3.61	0.55	3.61	0.65	3.61
22	0100	0.38	4.92	0.58	4.57	0.54	4.83	0.63	4.92
	0700	0.30	4.20	0.53	5.12	0.50	9.14	0.58	5.02
	1300	0.35	4.83	0.58	5.57	0.51	5.33	0.66	5.45
	1900	0.32	3.33	0.67	4.00	0.63	3.88	0.70	4.49
23	0100	0.36	4.20	0.79	8.00	0.81	7.53	0.93	5.95
	0700	0.38	4.57	0.90	7.53	0.95	7.31	1.04	7.53
	1300	0.41	5.82	0.77	5.82	0.76	5.45	0.83	6.40
	1900	0.29	4.34	0.66	7.53	0.65	4.66	0.74	6.09
24	0100	0.30	4.34	0.63	4.57	0.61	4.66	0.66	4.66
	0700	0.19	8.83	0.55	8.26	0.58	7.76	0.61	8.00
	1300	0.28	8.53	0.57	8.00	0.59	7.53	0.59	7.76
	1900	0.20	8.83	0.53	8.26	0.56	8.53	0.57	8.53
25	0100	0.24	7.76	0.48	8.83	0.50	8.00	0.55	8.26
	0700	0.18	4.74	0.46	8.00	0.52	8.26	0.55	7.53
	1300	0.27	8.53	0.48	7.53	0.52	8.26	0.56	8.00
	1900	0.18	8.00	0.41	7.76	0.45	8.00	0.48	8.26
26	0100	0.22	14.22	0.41	8.26	0.46	8.00	0.49	7.53
	0700	0.19	12.19	0.41	11.64	0.47	11.64	0.48	11.64
	1300	0.26	10.67	0.47	10.67	0.51	10.67	0.55	10.67
	1900	0.26	9.85	0.55	9.85	0.57	10.24	0.62	10.24
27	0100	0.27	9.48	0.51	9.85	0.59	10.24	0.63	9.85
	0700	0.24	9.85	0.55	9.48	0.52	9.48	0.67	9.48
	1300	0.26	8.83	0.46	8.53	0.52	8.53	0.52	8.53
	1900	0.23	8.26	0.46	8.26	0.47	8.26	0.51	8.26
28	0100	0.21	10.24	0.45	9.85	0.46	9.85	0.51	8.53
	0700	0.19	9.14	0.43	8.83	0.43	9.48	0.46	8.53
	1300	0.24	11.64	0.47	11.64	0.58	11.64	0.52	11.64
	1900	0.33	11.64	0.59	11.64	0.58	11.13	0.67	10.67
29	0100	0.25	11.64	0.49	11.64	0.56	11.64	0.68	11.64
	0700	0.37	10.67	0.65	10.67	0.70	11.64	0.85	11.13
	1300	0.44	11.13	0.67	11.13	0.73	11.13	0.80	11.13
	1900	0.75	12.19	Gauge		1.02	11.64	1.26	11.13
30	0100	0.99	12.80	Inoperative		1.40	12.19	1.52	11.64
	0700	1.17	12.19	1.45	11.64	1.58	11.13	1.93	11.64
	1300	1.04	12.19	1.41	11.64	1.54	11.64	1.73	12.19
	1900	1.18	11.64	1.53	11.64	1.86	12.80	1.87	12.80
31	0100	1.13	11.64	1.84	11.64	1.86	11.64	Inoperative	
	0700	1.27	11.64	1.87	11.13	1.94	11.13	2.14	11.64
	1300	1.17	11.64	2.22	11.13	2.49	12.19	2.69	11.64
	1900	1.76	13.47	3.42	12.80	4.32	12.19	4.81	12.19
Mean		0.35	7.82	0.67	8.14	0.72	8.31	0.79	8.21
Std dev		0.26	2.90	0.40	2.06	0.48	2.13	0.51	2.00

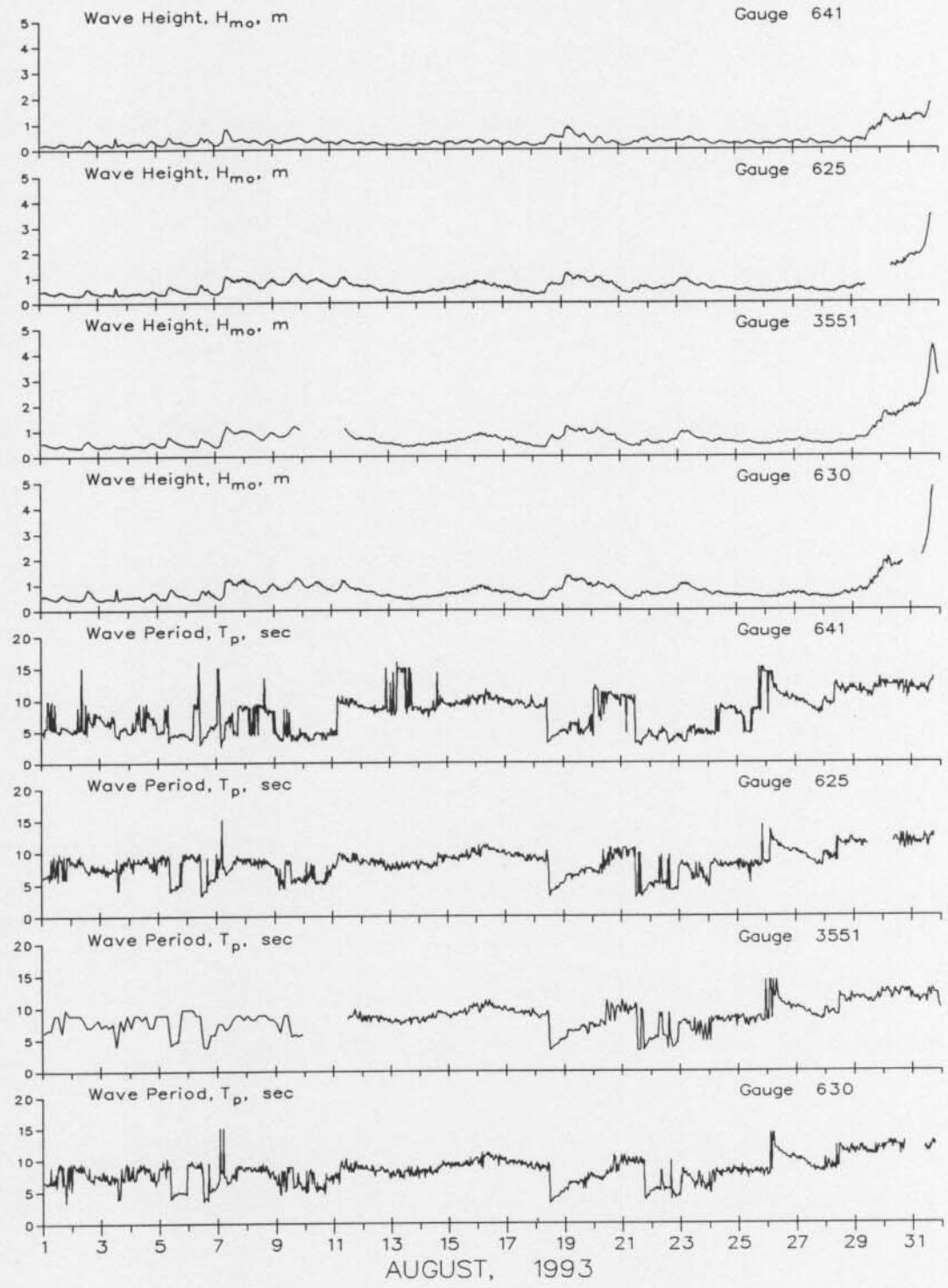


Figure 5. Time History of Wave Heights and Periods

4 Current Data

Current data (Table 5) are collected from a Marsh-McBirney electromagnetic biaxial current meter and by visually observing the movement of dye on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier, approximately 12 m offshore (Table 6).

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or off-shore (eastward). All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the cross-shore and longshore data. Current directions indicate the direction that the current is moving towards.

Table 5
Current Meter Data - Gauge 559

August 1993

Cross Long				Cross Long				Cross Long							
Day	Time	Shore	Speed	Day	Time	Shore	Speed	Day	Time	Shore	Speed				
		Dir				Dir				Dir					
1	100			1300	-4	0	5	246	22	100	-1	1	2	234	
	700			1900	-1	10	10	168		700	0	-4	5	324	
	1300			12	100	-5	4	216		1300	4	11	11	139	
	1900				700	0	22	22	159		1900	-2	9	9	178
2	100			1300	-1	6	6	183	23	100	-2	9	9	176	
	700			1900	-3	3	5	209		700	-1	-2	4	315	
	1300			13	100	-3	-3	297		1300	4	0	4	56	
	1900				700	-2	0	3	245		1900	0	-12	13	340
3	100			1300	-2	-9	10	322	24	100	0	-10	11	333	
	700			1900	4	-11	13	358		700	0	-14	15	335	
	1300			14	100	2	-5	6	360		1300	5	-20	22	353
	1900				700	-4	2	5	226		1900	1	-19	20	343
4	100	Gauge		1300	-1	0	2	262	25	100	-1	-17	18	334	
	700			1900	-2	5	6	188		700	0	-9	10	335	
	1300			15	100	-2	2	4	220		1300	5	-36	37	348
	1900				700	-3	12	12	177		1900	-2	-19	20	332
5	100			1300	-9	19	21	188	26	100	0	-6	7	343	
	700			1900	-6	18	19	180		700	-2	4	5	200	
	1300	Inoperative		16	100	-3	12	13	180		1300	1	-13	14	343
	1900				700	-7	15	17	186		1900	-6	-6	10	298
6	100			1300	-7	7	11	210	27	100	-3	-9	11	317	
	700			1900	-3	4	6	205		700	-4	0	5	251	
	1300			17	100	-4	2	6	232		1300	8	-11	15	14
	1900				700	-2	-3	5	301		1900	-5	-5	9	298
7	100			1300	-1	-8	9	329	28	100	-2	-8	9	320	
	700			1900	-4	-5	8	299		700	-3	-1	4	276	
	1300			18	100	0	-2	3	321		1300	-2	-12	13	329
	1900				700	-3	6	7	198		1900	0	-8	9	335
8	100			1300	12	19	22	127	29	100	0	-9	10	332	
	700			1900	3	1	3	88		700	3	0	3	72	
	1300			19	100	-4	33	33	168		1300	4	-5	8	16
	1900				700	-3	37	37	167		1900	-2	-3	5	301
9	100			1300	-5	29	30	171	30	100	-2	5	5	188	
	700			1900	0	9	9	158		700	-6	12	14	189	
	1300			20	100	-3	13	13	179		1300	7	23	24	144
	1900				700	3	17	17	151		1900	4	17	18	147
10	100			1300	-4	9	10	188	31	100	0	34	34	161	
	700			1900	-5	-15	17	319		700	-1	22	22	165	
	1300			21	100	0	-22	23	337		1300	-4	52	52	165
	1900				700	-2	-16	18	330		1900	10	25	27	139
11	100			1300	7	-3	8	42							
	700			1900	4	-9	11	3							

KEY:

- +crossshore = offshore, cm/sec
- crossshore = onshore, cm/sec
- +longshore = south, cm/sec
- longshore = north, cm/sec
- Speed = Resultant speed, cm/sec
- Dir = Resultant direction, degrees true north

Table 6
Visually Observed Current Data

August 1993												
	Pier End				Mid-Surf Zone				Beach			
Day	Cross Shore	Long Shore	Speed	Dir	Cross Shore	Long Shore	Speed	Dir	Location	Speed	Dir	
1	-7	12	13	191	0	0	0		South	15	N	
2	24	-24	34	25	14	-17	22	19	South	14	N	
3	13	-18	22	15	12	-20	24	11	South	39	N	
4	0	0	0		0	0	0		South	19	N	
5	-7	28	29	174	7	22	23	143	South	5	S	
6	-15	30	34	187	0	0	0		South	14	N	
7	4	38	38	154	18	36	40	133	South	35	S	
8	-2	36	36	163	4	28	28	151	South	47	S	
9	-7	47	47	169	6	21	22	143	South	12	S	
10	-7	36	37	171	6	28	28	149	South	37	S	
11	-2	34	34	163	13	18	23	125	South	41	S	
12	-3	29	29	166	0	0	0		South	30	S	
13	0	0	0		0	0	0		South	1	S	
14	No observation				No observation				No observation			
15	No observation				No observation				No observation			
16	2	20	20	154	3	17	17	151	South	5	S	
17	1	-2	2	13	7	-13	15	9	South	4	N	
18	4	22	22	149	2	16	16	154	North	11	S	
19	0	76	76	160	0	47	47	160	South	97	S	
20	5	18	19	146	0	0	0		North	49	S	
21	0	0	0		9	15	17	129	North	16	N	
22	-7	14	16	187	-5	9	10	187	North	26	S	
23	0	0	0		0	11	11	160	North	25	S	
24	0	17	17	160	-7	9	11	197	South	13	N	
25	0	-36	36	340	0	-12	12	340	South	26	N	
26	8	-34	35	354	4	-16	16	354	South	43	N	
27	0	-29	29	340	0	-44	44	340	South	31	N	
28	13	-17	22	17	22	-44	49	7	South	26	N	
29	13	-13	18	25	0	-38	38	340	South	53	N	
30	-2	-19	19	334	0	-87	87	340	South	35	N	
31	-3	30	31	166	-10	-68	68	331	North	23	N	

KEY:

+crossshore = offshore, cm/sec
- crossshore = onshore, cm/sec
+longshore = south, cm/sec
-longshore = north, cm/sec
Speed = Resultant speed, cm/sec
Dir = Resultant direction, degrees true north

5 Visual Observations

Visual wave direction measurements (Table 7) of both the primary wave train (i.e. that having the higher wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The direction of the primary wave train just north of the seaward end of the pier is also determined using a Raytheon Marine Pathfinder radar and measuring the alignment of the wave crests at approximately the same location as the visual measurements. The pier axis (considered perpendicular to the beach at the FRF) is oriented 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and visibility are also taken daily at the seaward end of the pier. A Bucket Thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The temperature is then read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the depth of visibility.

Table 7
Visual Observations

Day	Time	Wave Approach		Radar Wave Angle deg from True N	Width of Surf Zone,m	Water Characteristics		
		Primary	Angle at Pier End deg from True N Secondary			Temp.,C	Density g/cc	Secchi Vis.,m
1	0805	85			9	23.9	1.0200	4.6
2	0625	100			12	22.2	1.0200	4.0
3	0620	100			11	13.6	1.0244	2.4
4	0615	90		inoperative	15	12.5	1.0248	2.1
5	0620	40	95	inoperative	11	14.2	1.0244	3.4
6	0620	70		inoperative	11	19.7	1.0220	3.7
7	0855	35	80	inoperative	24	16.9	1.0233	5.2
8	0840	55		inoperative	20	17.8	1.0230	3.7
9	0635	80	40	inoperative	14	20.0	1.0203	3.0
10	0620	50	80	inoperative	12	21.7	1.0208	2.7
11	0610	80			23	22.8	1.0201	3.4
12	0610	85			9	23.9	1.0187	3.4
13	0610	90			14	21.7	1.0213	2.1
14	no observations made							
15	no observations made							
16	0625	75			21	23.9	1.0182	2.7
17	0600	75	125		10	19.2	1.0221	1.8
18	0715	20		inoperative	10	16.5	1.0235	1.5
19	0720	25		30	28	21.7	1.0204	2.7
20	0755	45		inoperative	88	22.2	1.0200	3.0
21	1000	5		inoperative	3	22.2	1.0210	2.4
22	1030	30		inoperative	5	24.4	1.0206	2.1
23	0820	75		inoperative	18	24.4	1.0206	3.0
24	0820	80			6	24.4	1.0207	3.7
25	0740	95		inoperative	23	24.4	1.0206	3.0
26	0750	80		inoperative	15	23.9	1.0210	3.0
27	0820	80			43	22.3	1.0215	2.7
28	0930	90			29	16.1	1.0237	1.5
29	0900	100		inoperative	47	15.8	1.0240	1.8
30	0730	100		inoperative	73	24.4	1.0218	3.7
31	0628	100	50	inoperative	134	25.0	1.0194	0.9

6 Water Levels

Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A Leupold-Stevens digital recording float-type tide gauge is used to collect instantaneous water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 6 along with a list of means and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level. Table 8 contains the range, high, low, and mean water level for each 12.42-hr tidal cycle.

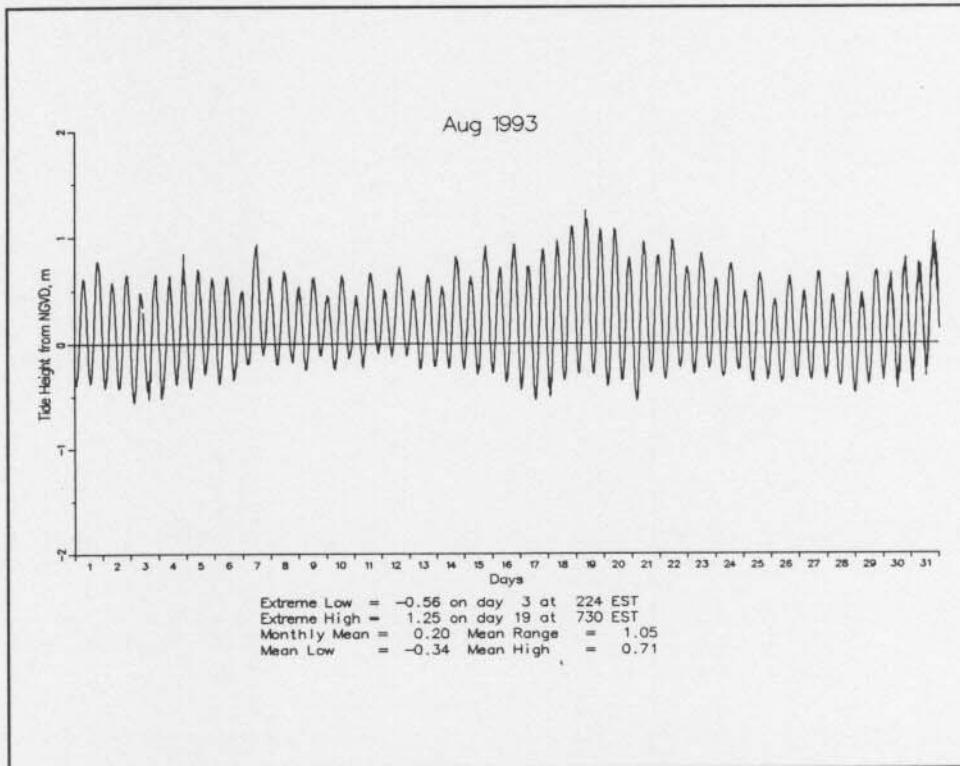


Figure 6. Water Level Time History

Table 8
Water Levels, m NGVD

August 93															
High			Low			Mean Range		High			Low			Mean Range	
Day	Time	m	Day	Time	m	m	m	Day	Time	m	Day	Time	m	m	
1	0630	0.61	1	0036	-0.39	0.11	1.00	16	1806	0.93	17	0012	-0.44	0.28 1.37	
1	1848	0.78	2	0048	-0.39	0.22	1.17	17	0624	0.73	17	1236	-0.53	0.13 1.26	
2	0712	0.58	2	0124	-0.42	0.07	1.00	17	1854	0.89	18	0112	-0.51	0.22 1.40	
2	1942	0.64	3	0130	-0.52	0.09	1.16	18	0712	0.97	18	0154	-0.40	0.27 1.37	
3	0712	0.48	3	0224	-0.56	-0.04	1.03	18	1936	1.10	18	1418	-0.30	0.42 1.40	
3	2100	0.65	3	1500	-0.52	0.06	1.18	19	0730	1.25	19	1418	-0.29	0.46 1.54	
4	0848	0.64	4	0248	-0.47	0.07	1.11	19	2018	1.07	20	0224	-0.41	0.36 1.48	
4	2042	0.84	5	0254	-0.43	0.12	1.27	20	0830	1.08	20	0336	-0.36	0.35 1.44	
5	0900	0.70	5	0324	-0.41	0.16	1.10	20	2124	0.81	21	0354	-0.55	0.17 1.36	
5	2124	0.62	6	0336	-0.38	0.13	1.00	21	0948	0.96	21	0430	-0.51	0.28 1.47	
6	1000	0.63	6	1530	-0.35	0.15	0.98	21	2242	0.84	22	0436	-0.34	0.25 1.18	
6	2254	0.50	6	1642	-0.33	0.10	0.83	22	1024	0.98	22	0518	-0.29	0.36 1.26	
7	1112	0.94	7	0506	-0.15	0.40	1.08	22	2300	0.72	23	0512	-0.29	0.22 1.01	
7	2242	0.64	8	0448	-0.20	0.20	0.84	23	1142	0.85	23	0606	-0.28	0.31 1.13	
8	1048	0.69	8	1806	-0.18	0.25	0.87	23	2348	0.61	24	0618	-0.32	0.16 0.93	
8	2312	0.54	9	0512	-0.25	0.14	0.80	24	1312	0.76	24	0706	-0.30	0.27 1.06	
9	1154	0.63	9	0648	-0.16	0.24	0.79	25	0112	0.50	25	0742	-0.36	0.08 0.86	
9	2348	0.46	10	0642	-0.25	0.12	0.70	25	1348	0.66	25	0818	-0.37	0.19 1.03	
10	1242	0.64	10	0742	-0.18	0.25	0.82	26	0248	0.41	26	0824	-0.38	0.02 0.79	
11	0112	0.46	11	0718	-0.24	0.11	0.69	26	1454	0.63	26	0836	-0.36	0.16 0.99	
11	1306	0.67	11	0830	-0.11	0.29	0.78	27	0348	0.50	27	0918	-0.34	0.06 0.84	
12	0136	0.52	12	0800	-0.13	0.18	0.64	27	1606	0.68	27	0948	-0.35	0.19 1.02	
12	1454	0.72	12	2054	-0.12	0.32	0.84	28	0354	0.46	28	1012	-0.40	0.04 0.86	
13	0254	0.51	13	0842	-0.24	0.14	0.75	28	1642	0.66	28	2236	-0.45	0.11 1.11	
13	1554	0.64	13	2130	-0.21	0.22	0.86	29	0524	0.48	28	2330	-0.48	0.01 0.95	
14	0354	0.55	14	0948	-0.24	0.15	0.78	29	1742	0.69	29	1118	-0.39	0.18 1.08	
14	1612	0.82	14	2306	-0.24	0.33	1.07	30	0618	0.66	30	1142	-0.44	0.14 1.10	
15	0500	0.63	15	1100	-0.30	0.18	0.93	30	1906	0.81	30	1230	-0.36	0.22 1.17	
15	1736	0.92	15	2342	-0.28	0.33	1.21	31	0618	0.77	31	0042	-0.37	0.23 1.14	
16	0612	0.72	16	1118	-0.37	0.18	1.09	31	1854	1.05	31	1318	-0.23	0.49 1.28	

7 Bathymetry

A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using the CRAB-Geodimeter surveying system; a Geodimeter 140-T self-tracking, electronic theodolite, distance meter, in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 7 shows the last survey in July 1993 and the survey(s) in August 1993 on profile line 188, located 517 m south of the pier.

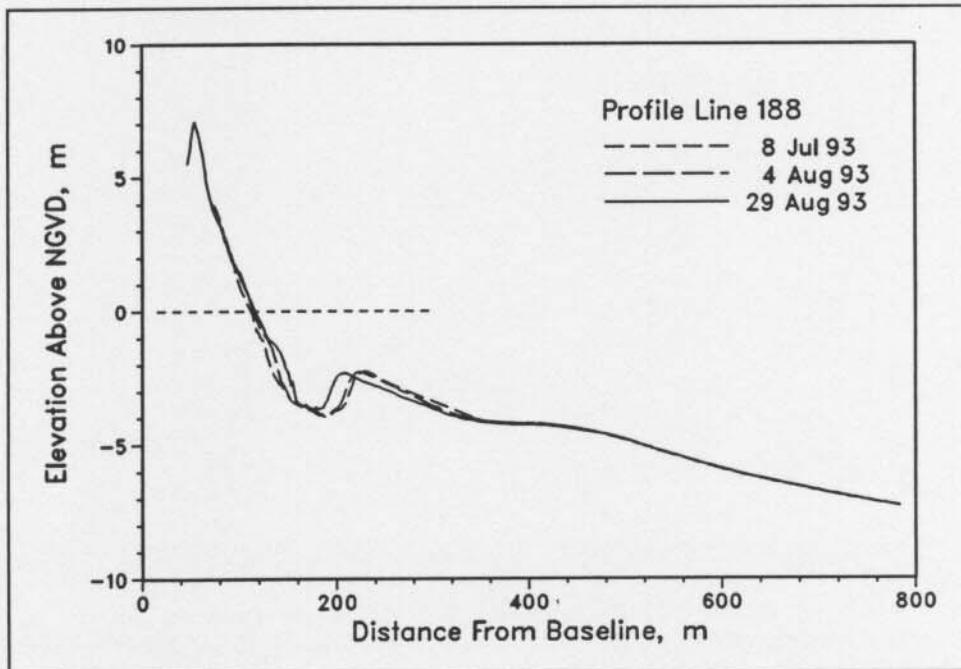


Figure 7. Monthly CRAB Profiles on Profile Line 188.

The profile envelope (Figure 8) reflects the maximum changes that occurred on the profile during 1993. Cross-hatched areas indicate changes to the annual envelope which occurred in August.

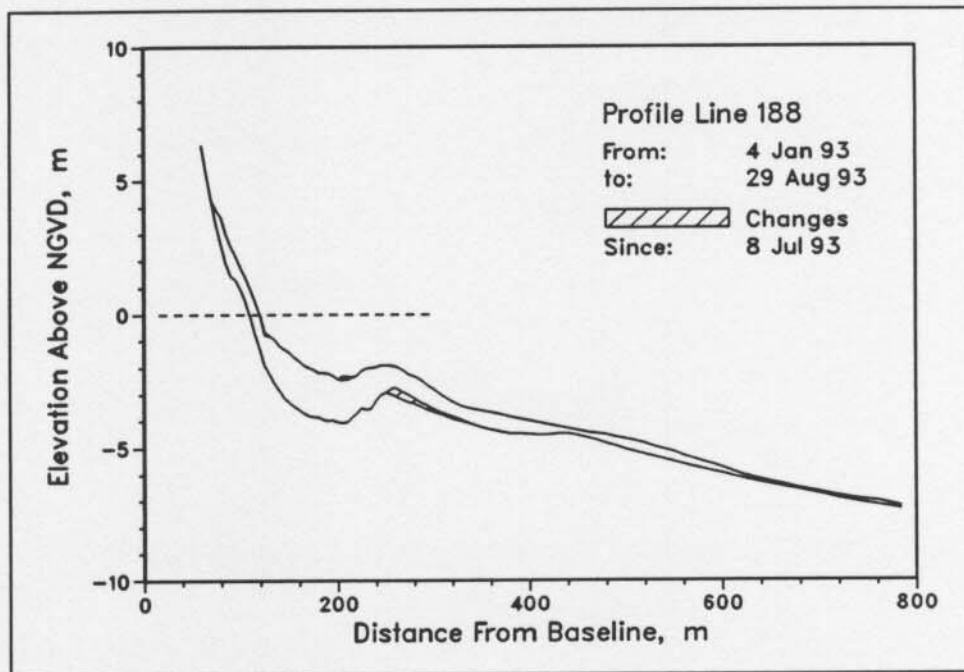


Figure 8. Profile Envelope - Profile Line 188.

B. Bathymetry. Figure 9 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 5 August. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.

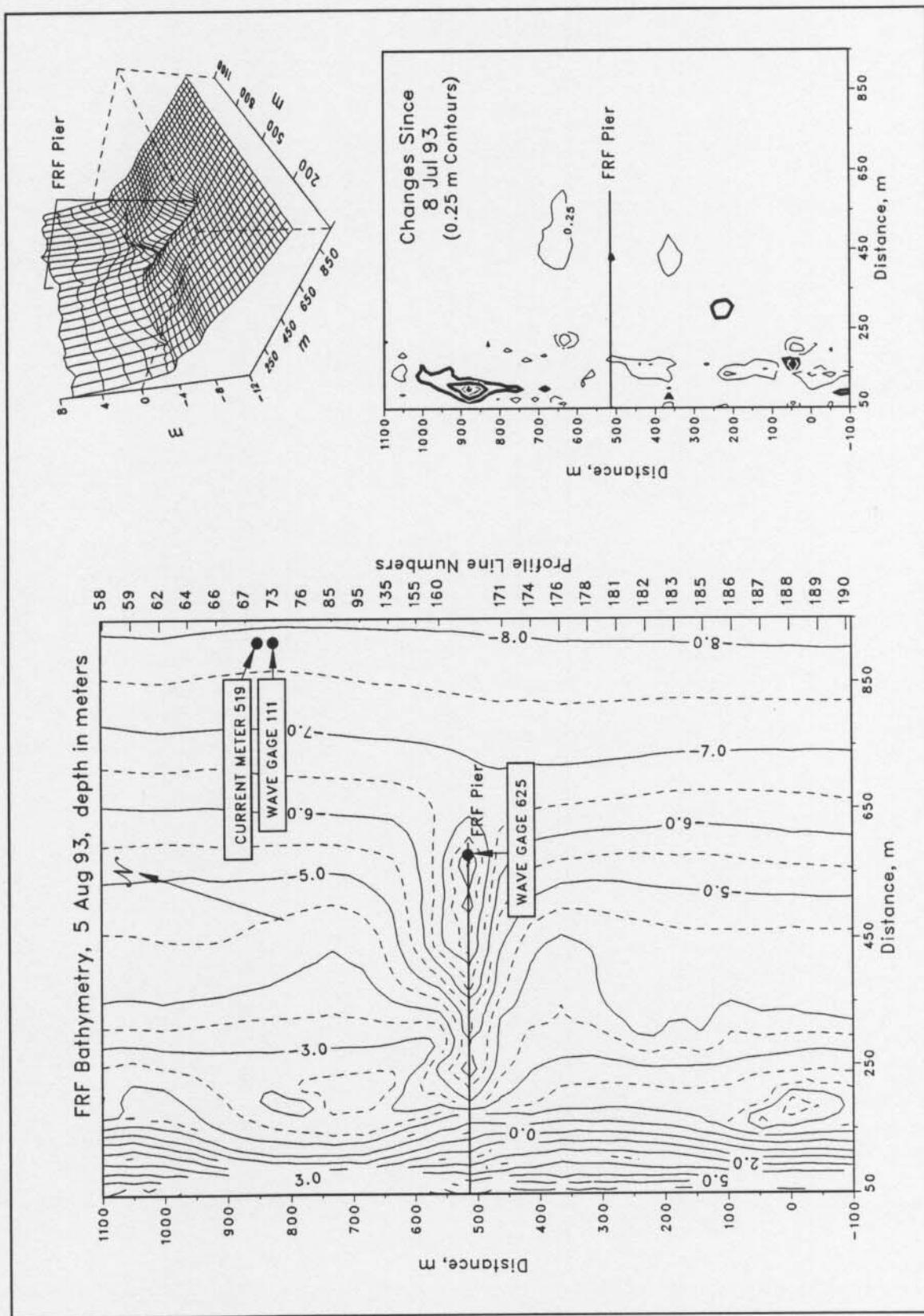


Figure 9. FRF Bathymetry, Depths Relative to NGVD

8 Special Events

A. Storm Data Collection. The following list identifies times when the wave height H_{mo} at the seaward end of the pier (i.e. as measured near the end of the pier) exceeded 2 m.

<u>Start</u>	<u>End</u>
31 Aug (1034)	01 Sep (0400)

B. Storm Synopsis.

Hurricane Emily developed in the mid-Atlantic, tracking a northwesterly course. By the morning of 31 August, Emily was less than 160km to the southeast of Cape Hatteras. Increasing in strength, Emily reached category 4 on the Saffir/Simpson Hurricane Scale with sustained winds of approximately 67 m/s. Interaction with a cold front turned Emily northeast, back to sea, as the eye passed only several km offshore of Cape Hatteras. The eye passed the FRF near midnight, on the 31st, about 50 km offshore. The maximum H_{mo} , at gauge 630, reached 4.8 m ($T_p=12.19$ s). Maximum winds at the FRF reached 19 m/s. There was no precipitation.

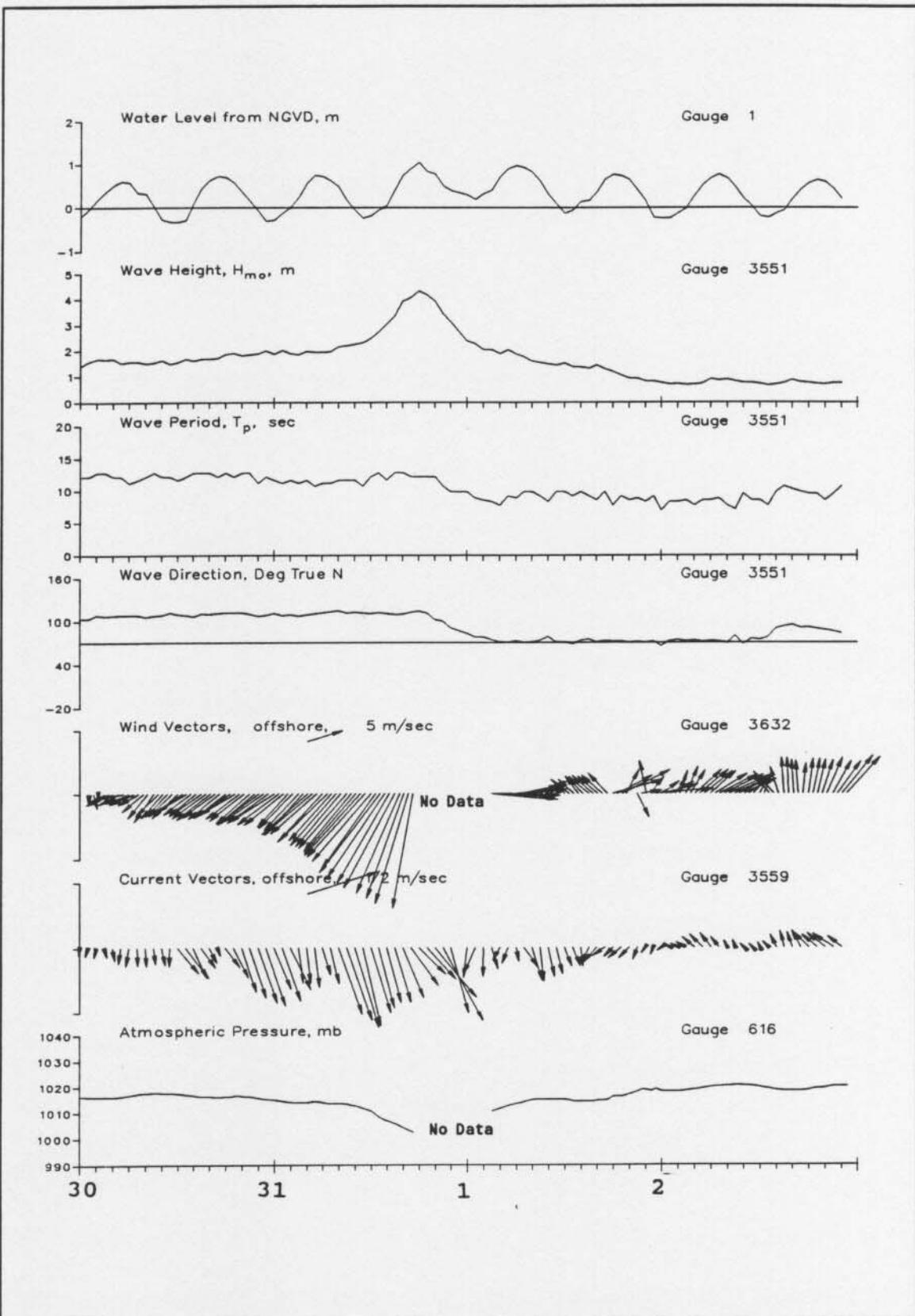


Figure 10. Hurricane Emily, 30Aug-2Sep

Distribution List

Government Agencies:

Back Bay National Wildlife Refuge	U.S. Geological Survey
USACE-OCE	U.S. Library of Congress
USACE-SAD	U.S. National Park Service
USACE-NAP	U.S. National Weather Service
USACE-SAW	U.S. Naval Academy
USACE-WES	U.S. Naval Civil Eng. Lab
NAVSAC	U.S. Naval Oceanographic Off.
NOAA/NOS/OMS	U.S. Naval Research Lab
National Marine Fisheries	

Colleges/Universities:

Bucknell University	Scripps Institution of Oceanography
California Inst. of Tech.	Stockton State College
Duke Marine Lab	University Calif-Berkeley
East Carolina University	University of Florida
Florida Inst. of Tech.	University of Maryland-College Park
M.I.T.	University of Maryland-Baltimore
Naval Post Graduate School	University of North Carolina
NC State University	University of N C-Seagrant Program
Old Dominion University	University of Virginia
Oregon State University	Va. Inst. of Marine Science
Prince George's College	Rutgers University

Others:

Allied Signal Aerospace Co.	WCTI-TV
Applied Physics Lab	MEC Systems Corporation
Cape Hatteras Nat. Seashore	Moffatt & Nichol, Eng.
Coastal and Est. Res., Inc.	N.C. Div. Coastal Management
Coastal Science & Eng., Inc.	Oregon Inlet & Waterways Commis.
Dr. Cy Galvin	Raleigh-Durham Airport
GEOMET Tech., Inc.	Mr. Rowland
Mr. Hodges	Mr. Savage
Dr. Hylton	Science Application Int'l. Corp
Mr. Mason	Sherwood Industries
Mr. Rodgers	SEASUN Power Systems

Foreign:

Christchurch, Barbados
Ministry of Works, Bahamas
Dalhousie University, Halifax Nova Scotia
Queen's University, Ontario (Canada)
Ministry of Construction, Coastal Division (Japan)
Norwegian Hydrodynamic Laboratories (Norway)
University of Sydney (Australia)